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DREO TECHNICAL NOTE NO. 75-21
DREO TN 75-21

## DEXTERITY AFFORDED BY CW PROTECTIVE GLOVES



by
P.V.Vittorio and S.W. Cattroll

PROJECT NO.
82-30-16

OCTOBER 1975
OTTAWA

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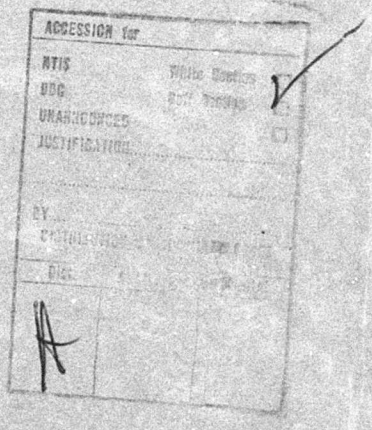

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(6) DEXTERITY AFFORDED BY CW PROTECTIVE GLOVES.

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Physiological Evaluation Group
NBC Defence Division

(7) Technical Note

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(11) Oct 75

(12) 33 p.

(14) DREO-TN-75-21

PROJECT NO.
82-30-16

RECEIVED OCTOBER 1975
PUBLISHED OCTOBER 1975
OTTAWA

75-198

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## ABSTRACT

The effects on manual performance of an experimental Canadian CW protective glove and US and UK CW protective gloves were compared using five different manual tasks. The results show that, statistically, performance in three of the manual dexterity tasks was significantly better with the US CW protective glove than with the Canadian or the UK CW protective gloves and in the same three tasks there was no significant difference in performance between the latter two gloves. Although the difference shown is statistically significant, its practical effect in the performance of military tasks may not be great.

## RÉSUMÉ

On a comparé les effets, sur le rendement manuel, de gants expérimentaux canadiens et de gants protecteurs américains et britanniques destinés à la guerre chimique, en effectuant cinq tâches manuelles différentes. Les résultats montrent que, statistiquement, le rendement est de beaucoup supérieur, en ce qui concerne trois des tâches de dextérité manuelle, quand elles sont exécutées avec les gants protecteurs américains destinés à la guerre chimique plutôt qu'avec les gants canadiens ou britanniques. On a également constaté qu'il n'y a aucune différence importante, dans le cas de ces trois mêmes tâches, entre les rendements des gants canadiens et britanniques. Bien que la différence entre les gants américains et les autres soit assez marquée du point de vue statistique, son effet sur l'exécution des tâches militaires peut se révéler de moindre importance.

## INTRODUCTION

The purpose of this study was to compare the effects on manual performance when wearing three different types of handwear designed to protect the wearer against CW agents. The effects of the three types of CW protective handwear on manual performance were determined for five different manual tasks. These five tasks are used routinely by AMCQM group at the U.S. Army Research Institute of Environmental Medicine, Natick, Mass. (1,2). The five tasks were chosen as being representative of a wide range of tasks involving manual and finger dexterity. Aspects of manual dexterity are measured which are judged to be important for performing military activities, and are sensitive to decrements in performance which result from the wearing of protective handwear. Three tasks were assumed to measure varying degrees of manual, finger, or fine finger dexterity. One task was a measure of proficiency in the use of wrenches and screwdrivers and one task was assumed to be related to firmness of grasp.

An earlier study by the present authors (3) showed that the manual dexterity tasks performed in this study could be performed better with the bare hand than with the Canadian CW protective glove (with or without the wool liner). McGinnis et al (2) reported that a comparison of the bare hand condition with the US Butyl CB protective glove showed performance was better with the bare hand. Thus present evidence indicates that the bare hand condition permits better manual performance than any of the glove conditions tested. Therefore, in this study only the three glove conditions were studied and the bare hand was omitted.

## METHOD

### Subjects

Six (6) members of the DREO/CF Test Team were used. They were young, male, active military personnel and ranged in age from 22 to 28 years. Their physical characteristics are given in Table I.

## Apparatus and Tasks

Testing was conducted in a laboratory maintained at approximately 70°F. The CF men who served as subjects were outfitted in Canadian Forces work dress. Five tasks were performed, and the method of performing each task has been described in an earlier report (3). The following tasks were performed:

1. Cord Manipulation and Cylinder Stringing Tests - a test designed by McGinnis to measure proficiency in handling soft, flexible materials (1,2). The apparatus is shown in Figure 1.

2. Minnesota Two-Hand Turning Test - a widely used test designed to measure manual dexterity (4). The apparatus is shown in Figure 2.

3. Bennett Hand Tool Dexterity Test - a test which measures proficiency in the use of wrenches and screwdrivers (5). The apparatus is shown in Figure 3.

4. O'Connor Fine Finger Dexterity Test - a test widely used for measuring fine finger dexterity and aptitude for assembling small mechanical parts. The apparatus is shown in Figure 4.

5. Torque Test - a test designed to measure the amount of angular force which can be applied to a 0.75 inch diameter cylinder when it is grasped in one hand. It is assumed that this task is closely related to the ability to hold onto objects and has little other relation to dextrous manipulation. The apparatus is shown in Figure 5.

The score for tests 1, 2, 3 and 4 was the time required to complete the given numbers of components on the task, recorded to the nearest 0.01 minutes. The score for the torque test was measured in in·lb.

## Procedure

The handwear systems investigated in this study were as follows:

a. An experimental Canadian Chemical Warfare protective glove

b. U.K. Chemical Warfare protective glove with liner

c. U.S. Chemical Warfare protective glove.

The three types of handwear investigated are shown in Figures 6, 7 and 8 respectively.

The UK CW protective glove was tested with the liner worn inside the protective glove since the liner is always worn with the UK CW protective glove. The Canadian and US CW protective gloves can be worn without a liner and were tested without the liner. In a previous report (3) the present authors have shown that there was no significant difference in manual dexterity when the Canadian CW protective glove was worn with or without the wool liner.

Tests were performed by groups of three subjects and each test was repeated seven times. The subjects had already performed each test fourteen times in an earlier trial so that it was decided that seven trials would be sufficient for the present comparisons. During each of the seven sessions the order of presentation of handwear conditions was random for each trio of subjects.

The data from each task were subjected to separate analysis of variance for the seven sessions.

## RESULTS AND DISCUSSION

The results obtained for all tests performed have been plotted and are shown in Figures 9, 10, 11, 12 and 13.

The results of the analysis of variance performed on session 1 through 7 for the Minnesota Turning Tests, the Cord Manipulation and Cylinder Stringing Test, the Bennett Hand Tool Dexterity Test and the O'Connor Fine Finger Dexterity Test are shown in Tables II, III, IV and V respectively. The Minnesota Turning Test showed a significant effect of sessions but there was no significant effect of interaction or of handwear (Table II). The Cord Manipulation and Cylinder Stringing Test, the Hand Tool Dexterity Test and the O'Connor Fine Finger Dexterity Test showed no significant effect of sessions or interaction, but all three did show a significant effect of handwear (Tables III, IV and V).

The Canadian CW protective gloves were damaged during the Torque Test so that the test could not be completed with the Canadian CW protective gloves. The firmer grip afforded by the experimental Canadian gloves permitted development of torque values in excess of 125 in·lb which caused separation of the inner and outer layers of rubber due to shear failure of an intermediate layer. The Torque Test results that were obtained are shown in Figure 13. The Canadian CW protective glove permitted greater torque values for the first two trials than the US gloves which in turn permitted greater

torque values than the UK gloves. Analysis of variance for the torque test, when only the US and UK CW protective gloves were considered, showed that the effect of sessions and of interaction were not significant. However, the effect of handwear was significant and the US glove permitted a significantly greater torque value (Table VI) than the UK glove. This means that the US glove permits one to grasp and hold onto objects better than is possible with the UK glove.

Since these tests were performed the problem causing shear failure in the torque test has been overcome. Experimental gloves otherwise similar to those tested, have now been produced which in preliminary trials have withstood much greater torque values without any damage.

A further comparison of the effect of the US, the UK and the Canadian CW protective gloves on manual performance showed that the US glove provided significantly better manual dexterity ($P = 0.005$) than the UK or Canadian gloves when performing the Bennett Hand Tool Dexterity Test, the Cord Manipulation and Cylinder Stringing Test and the O'Connor Fine Finger Dexterity Test (Table VI). Although the differences in dexterity shown are statistically different their practical effect in the performance of military duties is not necessarily significant. A comparison of the US and the Canadian CW protective gloves, for the same three tests, did not show any significant difference in the effect on manual dexterity (Table VI).

## CONCLUSIONS

A comparison of the effect of the Canadian, the US and the UK CW protective gloves on manual performance, using the tests described in the present study, indicated that the US CW protective gloves permitted the best manual dexterity performance. The Canadian and UK CW gloves exhibited no significant difference in relation to manual dexterity.

The Canadian experimental gloves produced the highest torque values, but were not able to withstand the shear and so were damaged. The torque test values for the US gloves, although not as high as those for the Canadian gloves, were very good, and the US gloves were able to withstand the pressure without suffering any damage.

## REFERENCES

1. McGinnis, J., Lockhart, J., and Bensel, C. "A Human Factors Evaluation of Cold-Wet Handwear". U.S. Army Natick Laboratories, Natick, Mass. Technical Report 73-23-PR, April 1972.

2. McGinnis, J., Bensel, C. and Lockhart, J. "Dexterity Afforded by CB Protective Gloves". U.S. Army Natick Laboratories, Natick, Mass. Technical Report 73-35-PR, March 1973.

3. Vittorio, P.V., Soper, D.J.G. and Cattroll, S.W. "Dexterity Afforded by Canadian Gloves". DREO Tech. Note No. 75-4, February 1975.

4. Betts, L. (Ed.). "Minnesota Rate of Manipulation Test Examiner's Manual". Educational Test Bureau, Educational Publishers, 1946, Minneapolis.

5. Bennett, G.K. "Hand Tool Dexterity Test Manual of Directions". New York: Psychological Corporation, 1965.

## ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the DREO/CF Test Team who, under the capable supervision of WO. A. Dalpé, were at all times most cooperative, and to Mr. R.W. Nolan for his assistance in the statistical analysis of the data.

ANNEX A

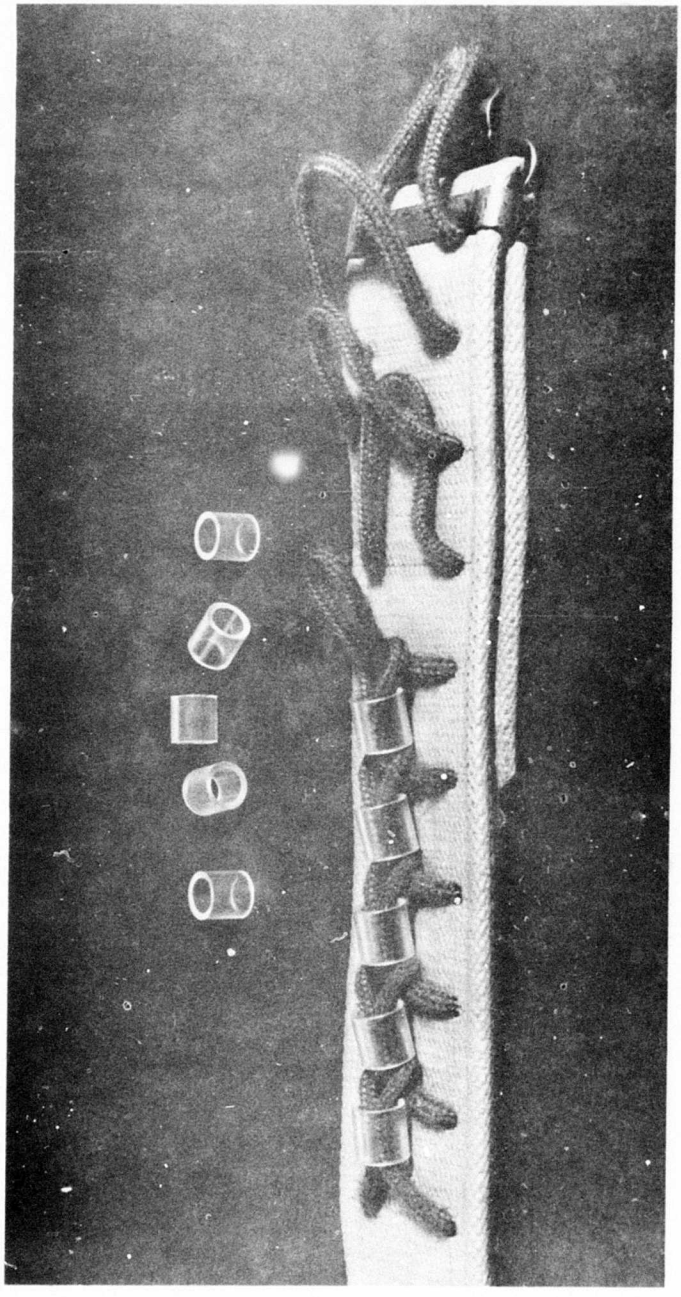

*Fig. 1 Cord Manipulation and Cylinder Stringing Test*

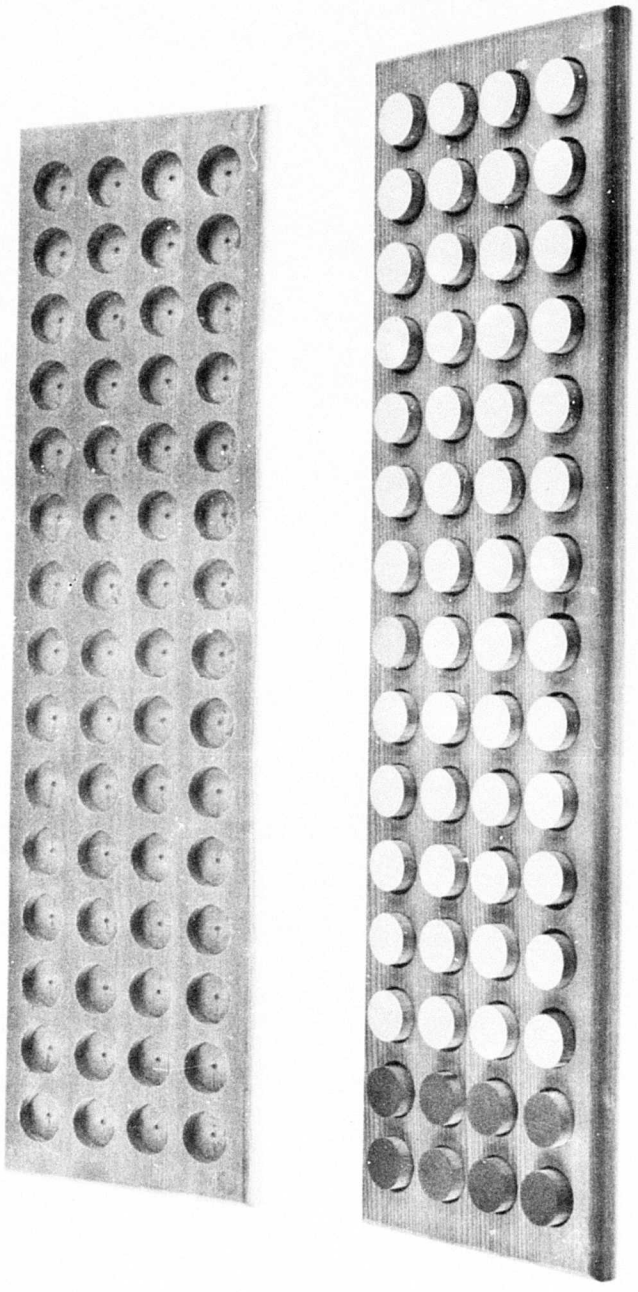

*Fig. 2 Minnesota Turning Test*

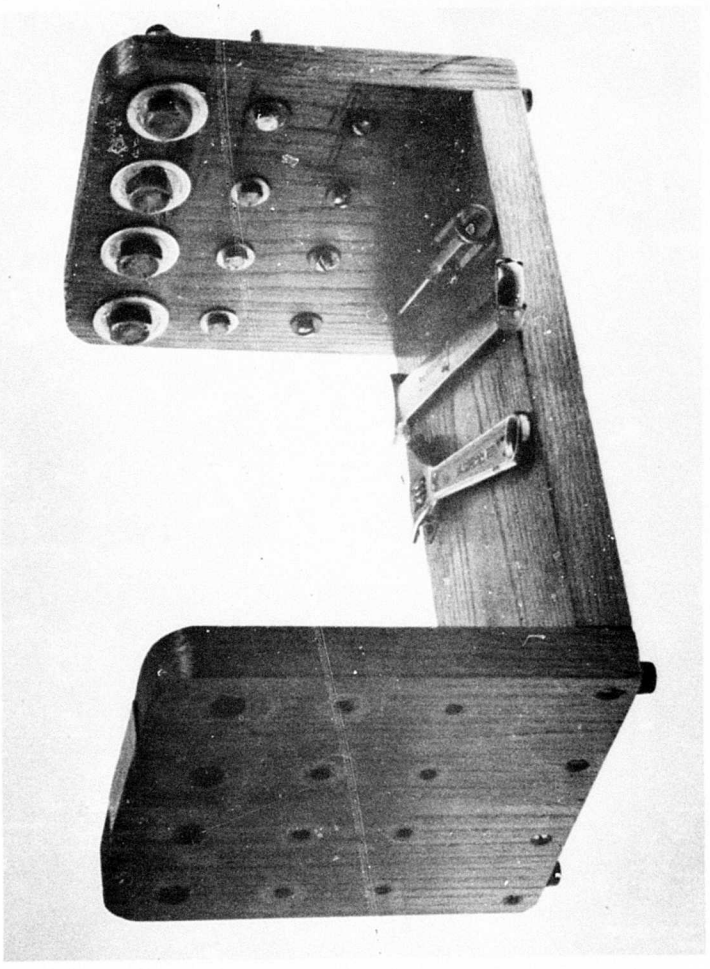

*Fig. 3 Bennett Hand Tool Dexterity Test*

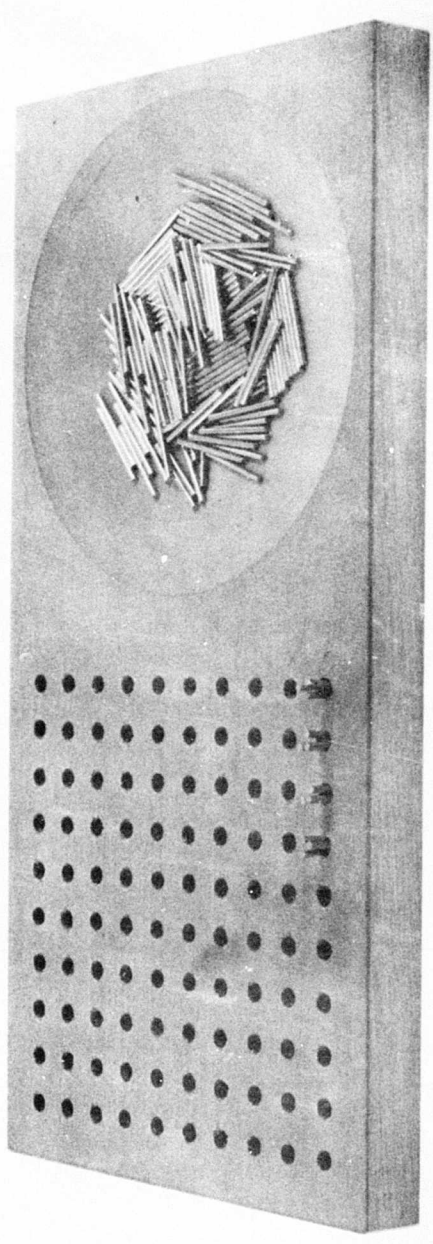

*Fig. 4 O'Connor Fine Finger Dexterity Test*

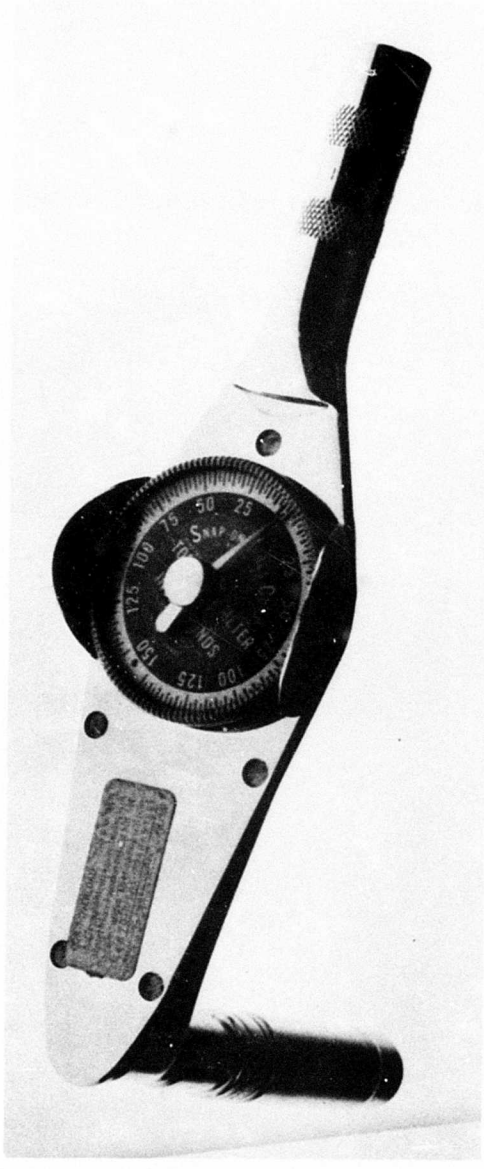


Fig. 5 Torque Test

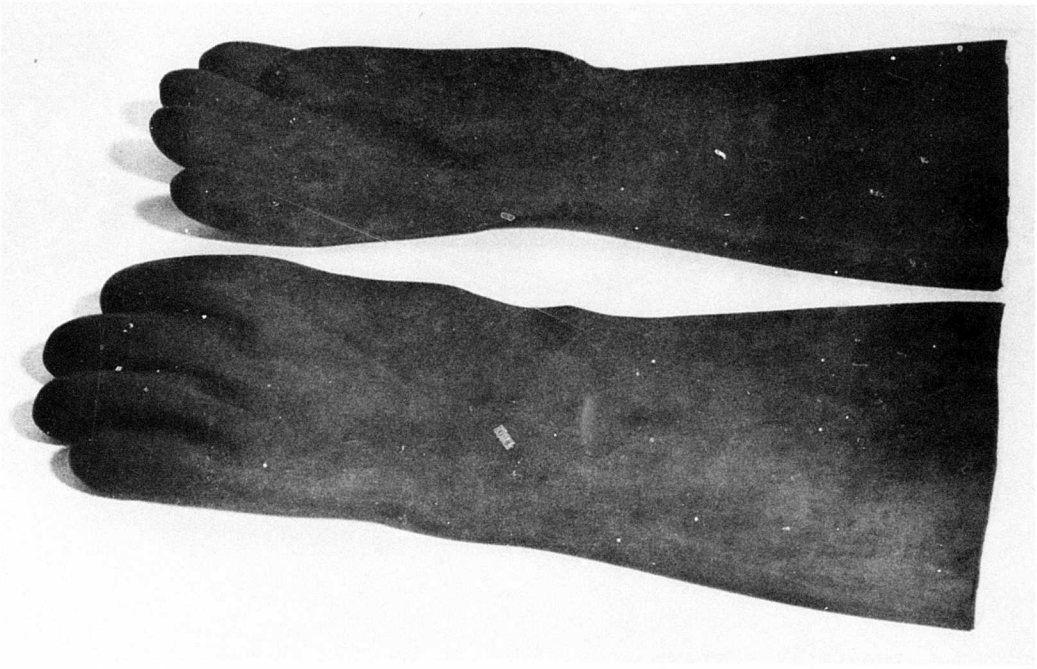

*Fig. 6 Canadian CW glove*


*Fig. 7 UK CW glove and cotton inner liner*


*Fig. 8 US CW glove*

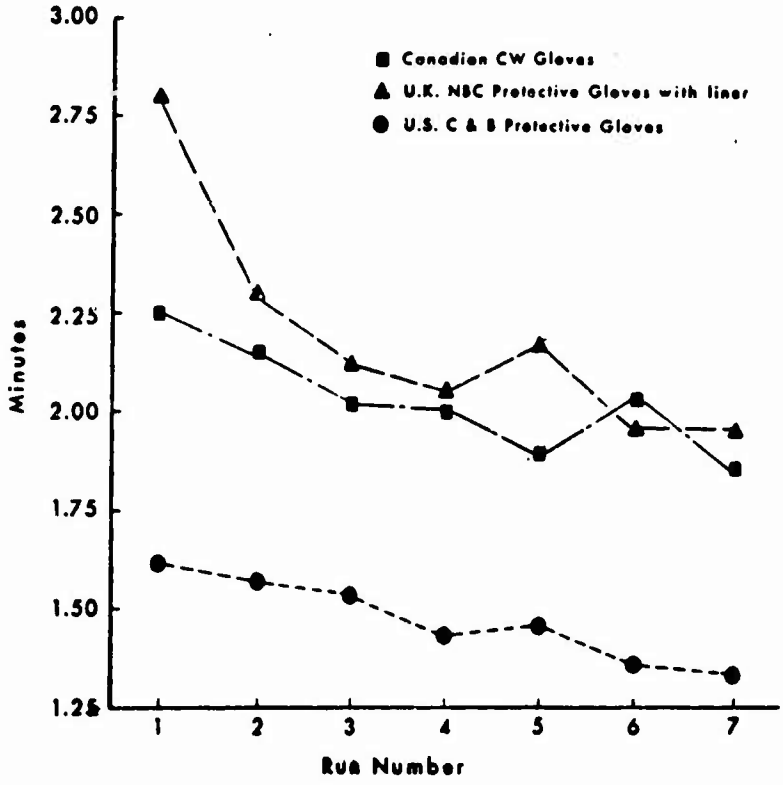


*Fig. 9 Cord Manipulation & Cylinder Stringing Test*

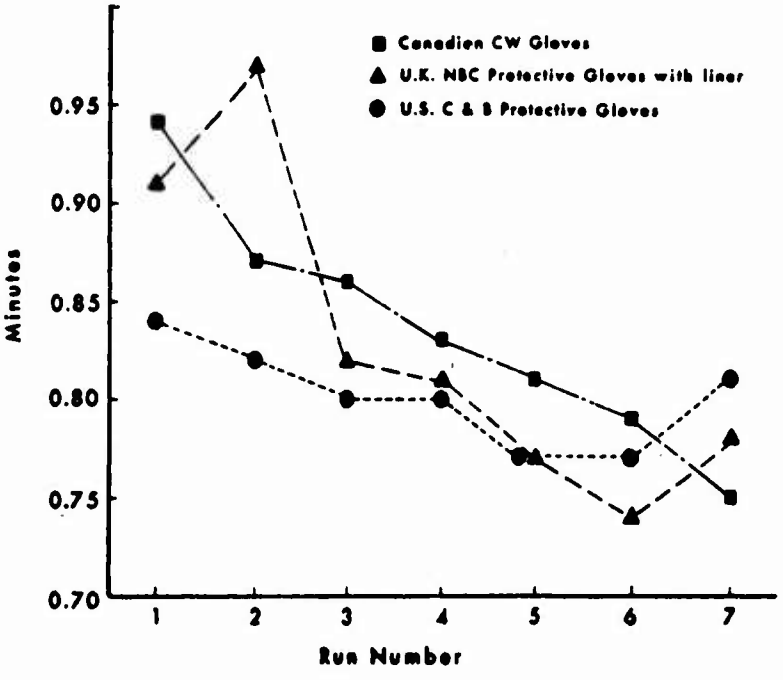


*Fig. 10 Minnesota Turning Test*

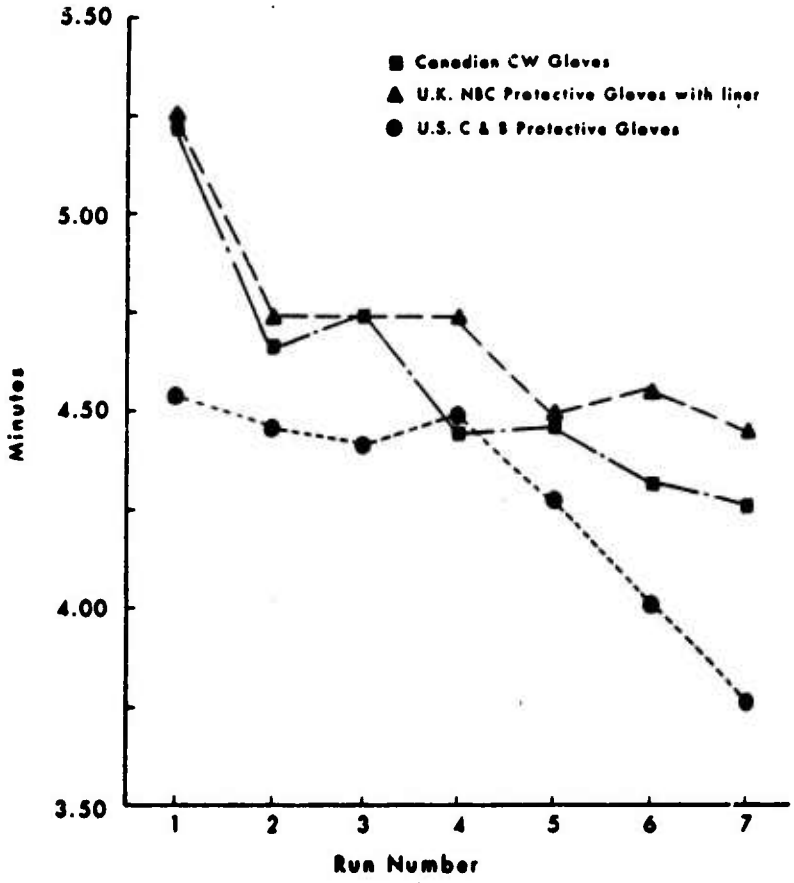


*Fig. 11 Bennett Hand Tool Dexterity Test*

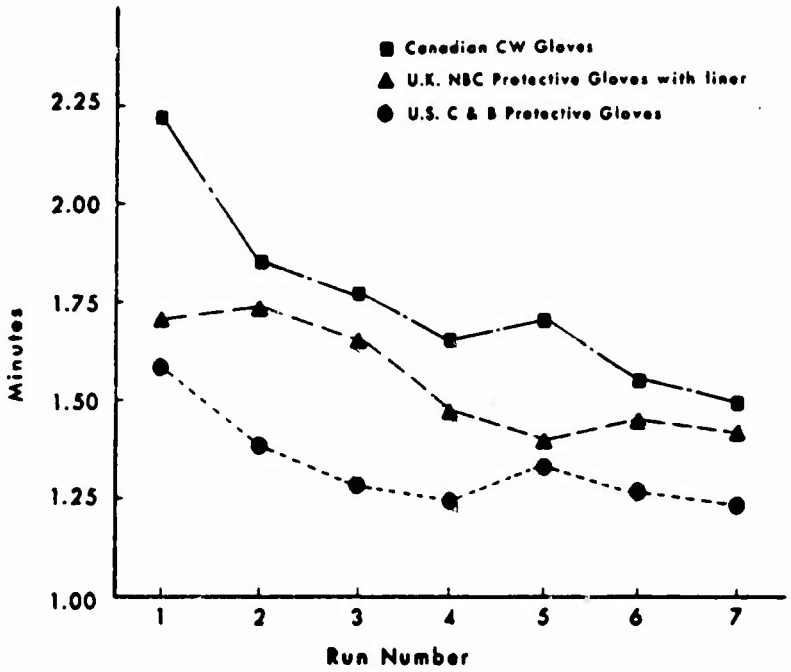


*Fig. 12 O'Connor Fine Finger Dexterity Test*

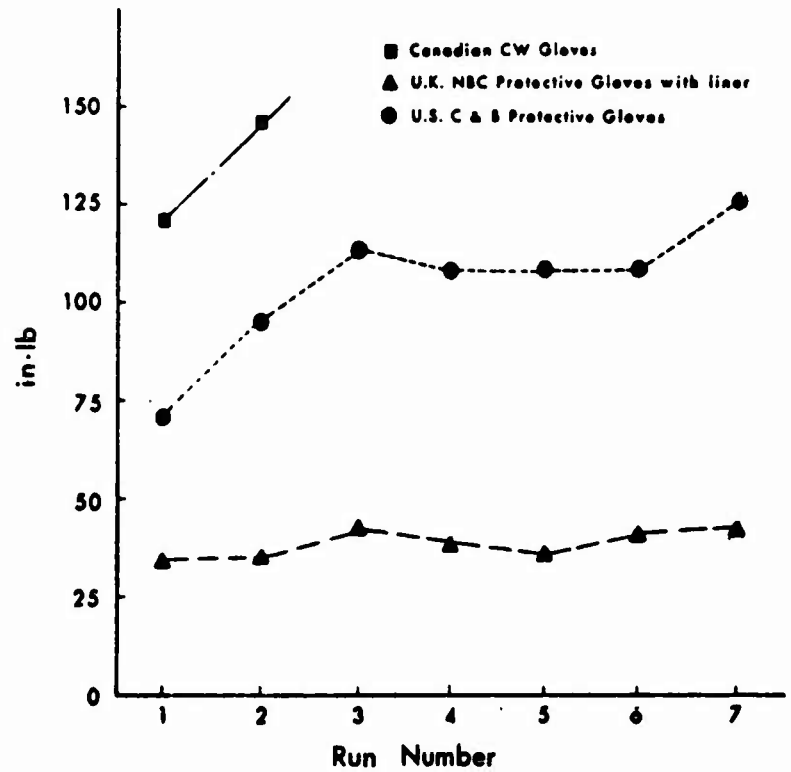


*Fig. 13 Torque Test*

TABLE I

Physical Characteristics of the Trial Subjects

| Subject No. | Age (years) | Body Weight (kg) | Height (cm) | Hand Size |
|---|---|---|---|---|
| 1 | 22 | 70.3 | 172.7 | Large |
| 2 | 25 | 68.6 | 165.1 | Small |
| 3 | 25 | 76.2 | 167.2 | Large |
| 4 | 26 | 66.8 | 172.7 | Medium |
| 5 | 28 | 63.6 | 171.5 | Medium |
| 6 | 24 | 63.5 | 172.0 | Medium |

TABLE II

Analysis of Variance of Minnesota Turning Test

Performance Data
(Sessions 1 - 7)

| Source of Variability | Sum of Squares | Degrees of Freedom | Mean Square | F-Ratio | F-Ratio Expected P = 0.005 level | Significance |
|---|---|---|---|---|---|---|
| Among Sessions | 0.26 | 5 | 0.04 | 4.76 | 3.33 | S |
| Among Handwear | 0.02 | 2 | 0.02 | 1.48 | 5.60 | NS |
| Interaction | 0.06 | 112 | 0.01 | 0.62 | 2.59 | NS |
| Subtotal | 0.36 | 20 | 0.02 | | | |
| With Treatments | 0.96 | 105 | 0.01 | | | |
| Total | 1.32 | 125 | 0.01 | | | |

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TABLE III

Analysis of Variance of Cord Manipulation and Cylinder Stringing Test

Performance Data
(Sessions 1 - 7)

| Source of Variability | Sum of Squares | Degrees of Freedom | Mean Square | F-Ratio | F-Ratio Expected P = 0.005 level | Significance P = 0.005 level |
|---|---|---|---|---|---|---|
| Among Sessions | 3.11 | 6 | 0.51 | 2.82 | 3.33 | NS |
| Among Handwear | 12.07 | 2 | 6.03 | 32.90 | 5.60 | S |
| Interaction | 1.07 | 12 | 0.08 | 0.48 | 2.53 | NS |
| Subtotal | 16.25 | 20 | 0.81 | | | |
| With Treatments | 19.25 | 105 | 0.18 | | | |
| Total | 35.51 | 125 | 0.28 | | | |


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TABLE IV

Analysis of Variance of Bennett Hand Tool Dexterity Test

Performance Data
(Sessions 1 - 7)

| Source of Variability | Sum of Squares | Degrees of Freedom | Mean Square | F-Ratio | F-Ratio Expected | Significance |
|---|---|---|---|---|---|---|
| | | | | | P = 0.005 level | |
| Among Sessions | 8.18 | 6 | 1.36 | 7.55 | 3.33 | NS |
| Among Handwear | 4.18 | 2 | 2.09 | 11.58 | 5.60 | S |
| Interaction | 1.40 | 12 | 0.11 | 0.64 | 2.53 | NS |
| Subtotal | 13.77 | 20 | 0.68 | | | |
| Within Treatments | 18.96 | 105 | 0.18 | | | |
| Total | 32.73 | 125 | 0.26 | | | |

TABLE V

Analysis of Variance of O'Connor Fine Finger Dexterity Test

Performance Data
(Sessions 1 - 7)

| Source of Variability | Sum of Squares | Degrees of Freedom | Mean Square | F-Ratio | F-Ratio Expected P = 0.005 level | Significance |
|---|---|---|---|---|---|---|
| Among Sessions | 2.72 | 6 | 0.45 | 2.91 | 3.33 | NS |
| Among Handwear | 3.68 | 2 | 1.84 | 11.80 | 5.60 | S |
| Interaction | 0.66 | 12 | 0.05 | 0.35 | 2.59 | NS |
| Subtotal | 7.06 | 20 | 0.35 | | | |
| Within Treatments | 16.36 | 105 | 0.15 | | | |
| Total | 24.42 | 125 | 0.18 | | | |

TABLE VI

Mean* Score for Each Task Under Each Handwear Condition

| Task | Handwear | | |
|---|---|---|---|
| Bennett Hand Tool Dexterity Test | 4.27<br>A | 4.59<br>C | 4.70<br>B |
| Cord Manipulation & Cylinder Stringing Test | 1.47<br>A | 2.03<br>C | 2.19<br>B |
| Minnesota Two Hand Turning Test | 0.80<br>A | 0.82<br>B | 0.84<br>C |
| O'Connor Fine Finger Dexterity Test | 1.33<br>A | 1.54<br>B | 1.75<br>C |
| Torque Test | 104<br>A | 38<br>B | |

Handwear not connected by the same line are significantly different at ($p = 0.005$)

A - American CW Glove B- UK CW Glove with Liner
C - Canadian CW Glove

* Mean value for 7 sessions
All tests in minutes except for Torque Test which is in in·lb.

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DEXTERITY AFFORDED BY CW PROTECTIVE GLOVES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
TECHNICAL NOTE

5. AUTHOR(S) (Last name, first name, middle initial)

VITTORIO, Paul V., CATTROLL, Stanley W.

| 6. DOCUMENT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
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| 8a. PROJECT OR GRANT NO. | 9a. ORIGINATOR'S DOCUMENT NUMBER(S) |
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13. ABSTRACT

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The effects on manual performance of an experimental Canadian CW protective glove and US and UK CW protective gloves were compared using five different manual tasks. The results show that, statistically, performance in three of the manual dexterity tasks was significantly better with the US CW protective glove than with the Canadian or the UK CW protective gloves and in the same three tasks there was no significant difference in performance between the latter two gloves. Although the difference shown is statistically significant, its practical effect in the performance of military tasks may not be great.

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